SURVIVAL OF PURE DISC GALAXIES OVER THE LAST 8 BILLION YEARS

Sonali Sachdeva (IUCAA)

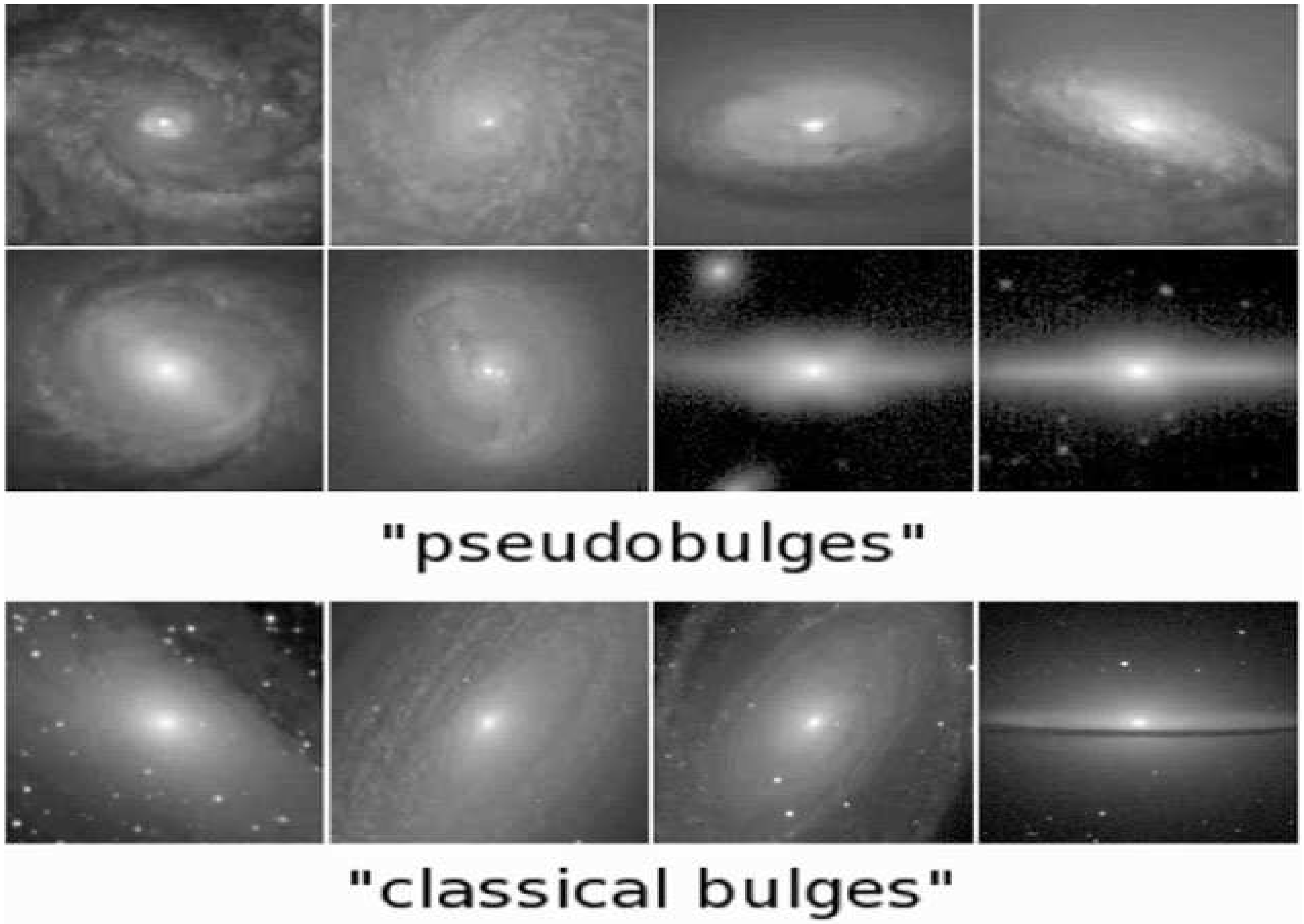
Discs in Galaxies 2016, ESO Garching

BASED ON

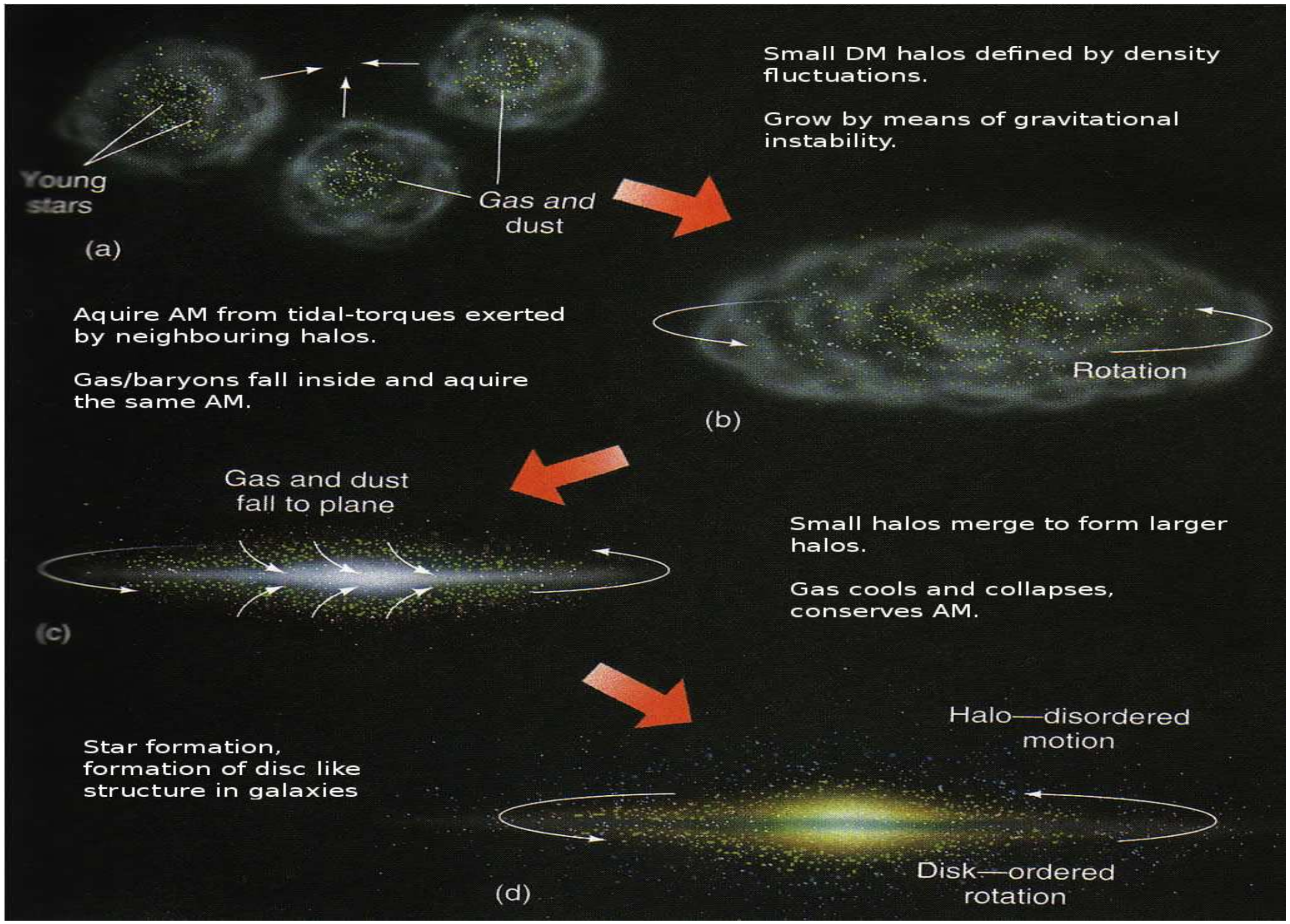
Sachdeva and Saha, ApJL, 2016

AAS NOVA Research highlights from the journals of the American Astronomical Society

http://aasnova.org/2016/04/04/forming-galaxies-without-bulges/



Bulges in disc galaxies
(Buta (2011))



LCDM galaxy formation picture
(Fall & Efstathiou (1980), White & Frenk (1991))

Major mergers

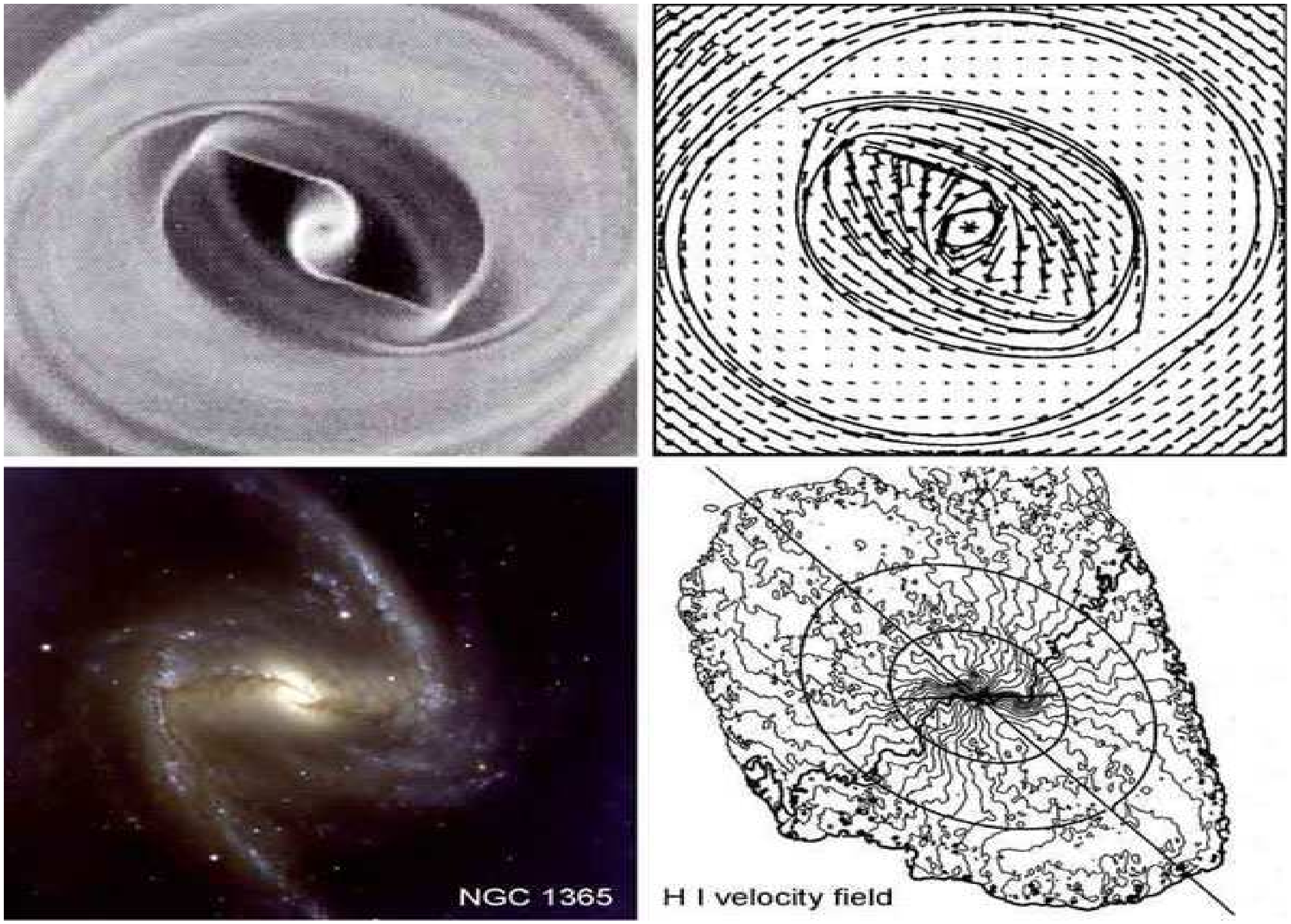
- **Method:** As halos merge, disks transformed into amorphous ellipsoids (Barnes and Hernquist, 1992). After merger, enough gas survives (i.e, experience insignificant angular momentum loss) to form a new, rotationally supported stellar disc around the remnant (Barnes and Hernquist 1996; Bournaud, Jog and Combes 2005; Hopkins et al. 2009).

- **Evidence:** For high-z galaxies close binary fractions increase as $(1+z)^m$ with m$\sim$2-3 (Bluck et al. 2009, 2012; Conselice et al. 2009; Tasca et al. 2014).

Minor mergers and accretion

- **Method:** Gas-poor minor mergers convert considerable fraction of stellar disk into bulge (Ostriker and Tremaine 1975; Toth and Ostriker 1992; Sellwood et al. 1998). Additionally, ongoing accretion of intergalactic debris displaces stars from disc orbits leading to bulge formation (Steinmetz and Navarro 2002, Parry, Eke and Frenk 2009).

- **Evidence:** From the observed satellite fractions. Simulations (Velazquez and White 1999; Naab and Burkert 2003; Bournaud et al. 2005; Younger et al. 2007, 2008).



Internal secular evolution: Mass & AM redistribution
(Athanassoula (2013), Sellwood (2014), Kormendy (2015))

Internal (secular) evolution

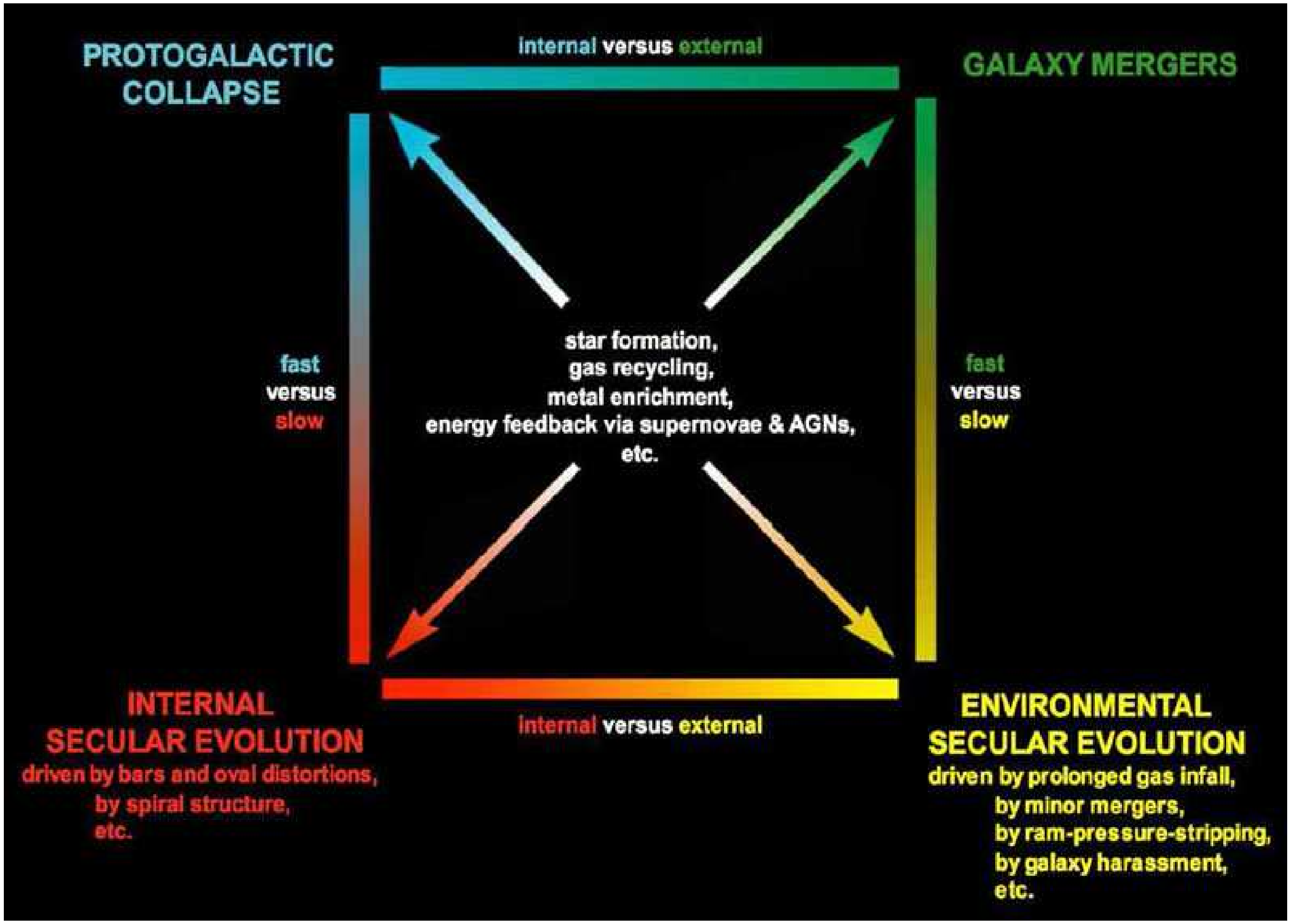
- **Method:** Self gravitating systems evolve, inner parts shrink, outer expand (Binney and Tremaine 2008, Kormendy 2012, Sellwood 2013). Facilitated by non-axis-symmetric structures (Athanassoula 2005, Combes 2008, Kormendy 2012, Sellwood 2013).

- **Evidence:** Bulges with disc like properties, i.e., flatter shapes, lower dispersion compared to luminosity (Peletier et al. 2007, Kormendy et al. 2010), starbursts, presence of structures (Kormendy and Kennicutt 2004), almost exponential profile (Fisher and Drory 2008, Gadotti 2009), lack of fundamental-plane correlation (Kormendy 2009).

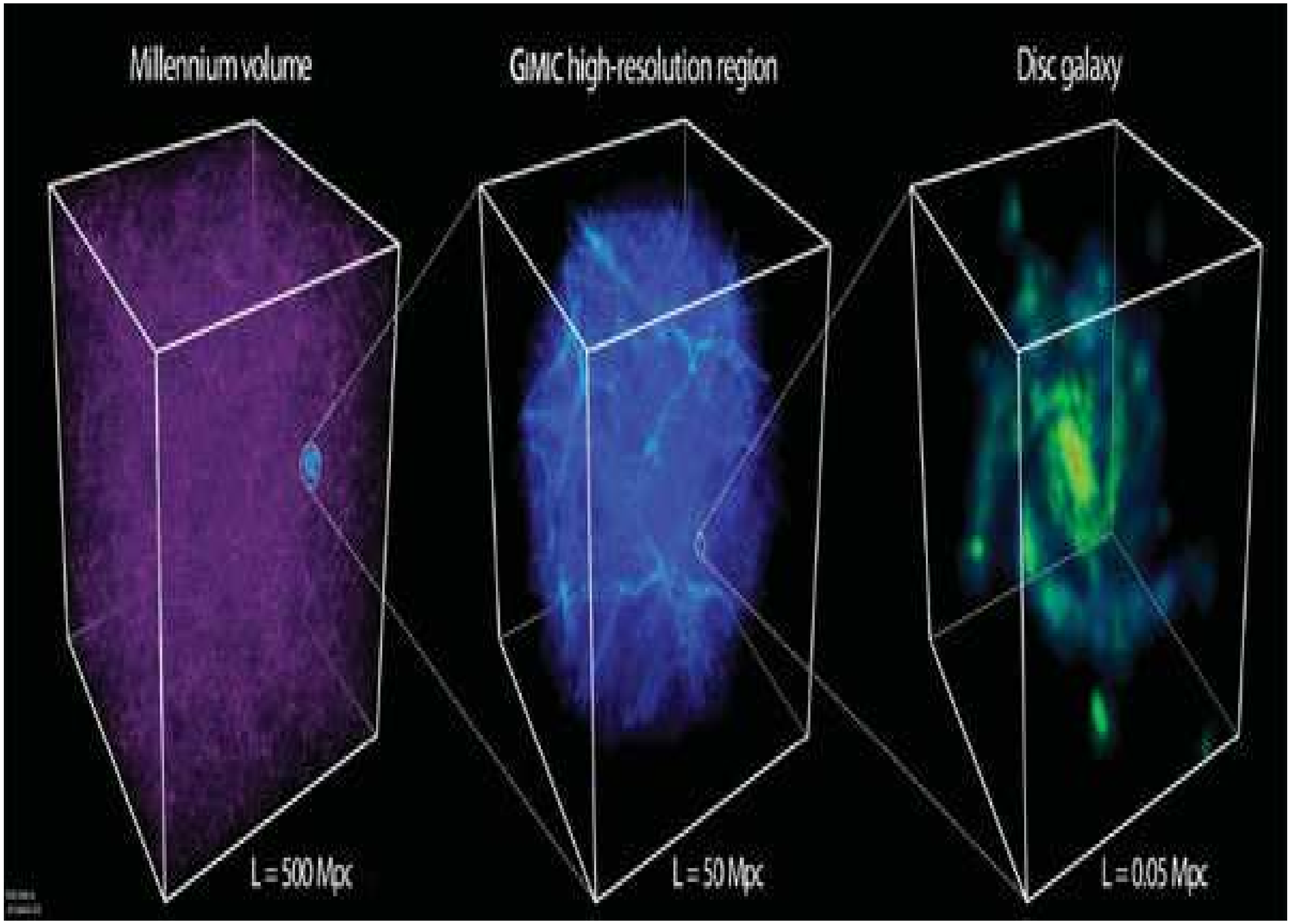
Clump coalascence

- **Method:** Local gravitational collapse of rapidly accreted cold gas with low velocity dispersion leads to clump formation. Clumps sink due to dynamical friction dumping additional cold gas via tidal torques (Toomre 1964, Elmegreen et al. 2005, Bournaud et al. 2011, Dekel et al. 2013).

- **Evidence:** High redshift discs dominated by 10^8 to 10^9 $M_\odot$, kpc size clumps observed and simulations (Bournaud et al. 2007, Elmegreen et al. 2009, Tacconi et al. 2010, Genzel et al. 2011, Forster Schreiber et al. 2011, Ceverino et al. 2015).

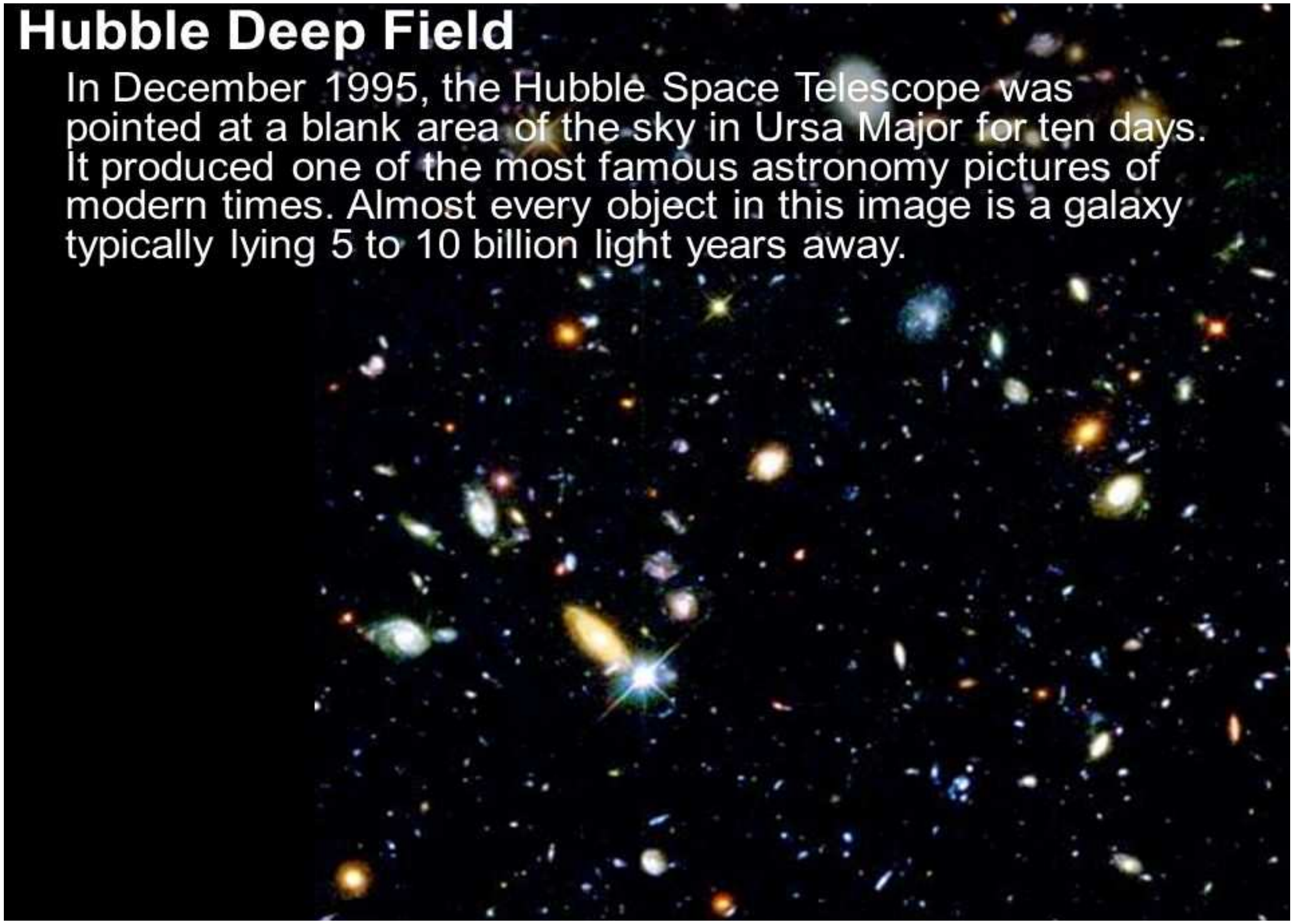


Internal or external: bulge does form
(detailed in: Kormendy (2013))

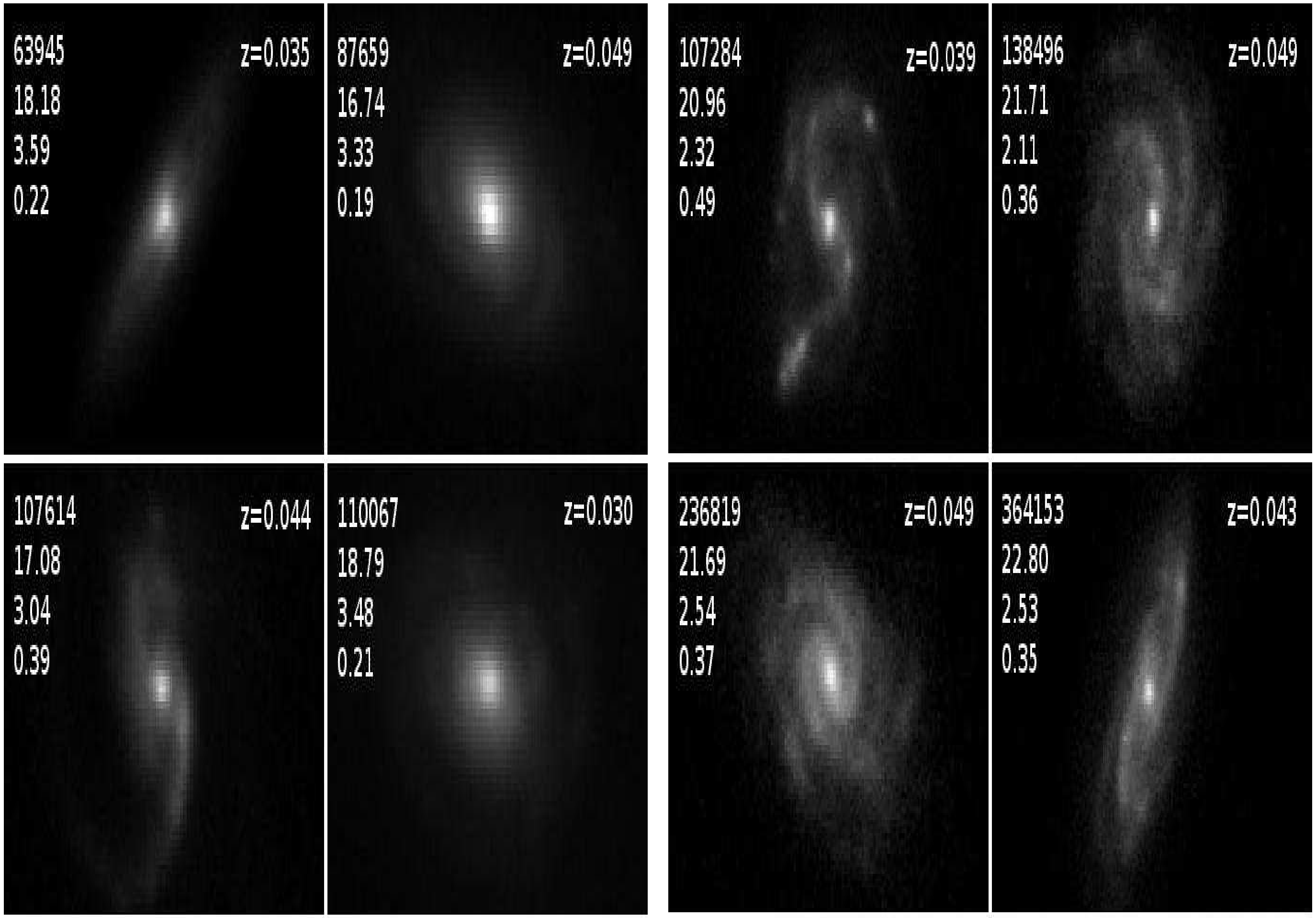


Forming discs without bulges
(Stinson et al. (2013), Marinacci et al. (2014))

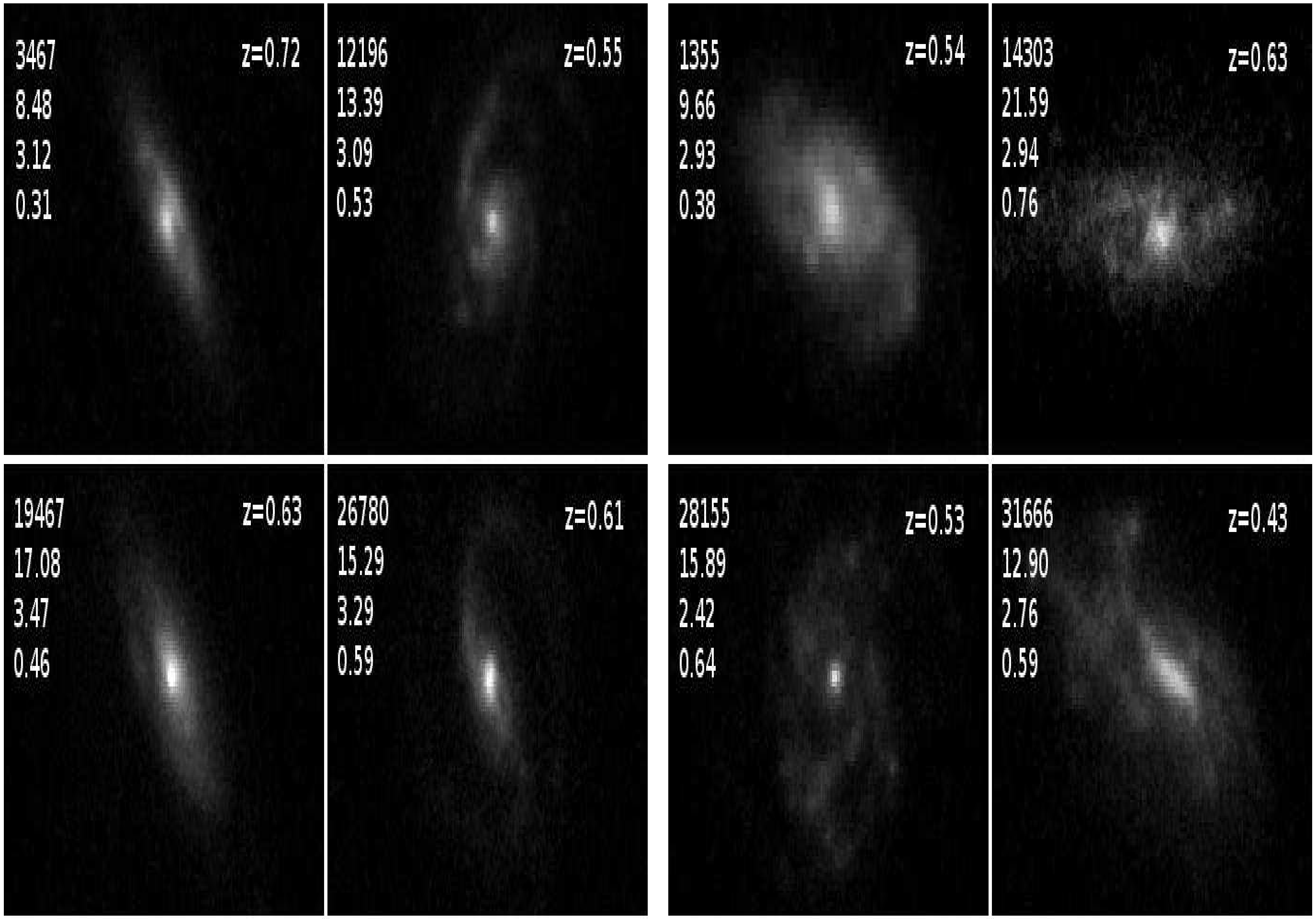
$35\% \pm 12\%$ of local disk galaxies bulgeless
(Fisher and Drory (2011))



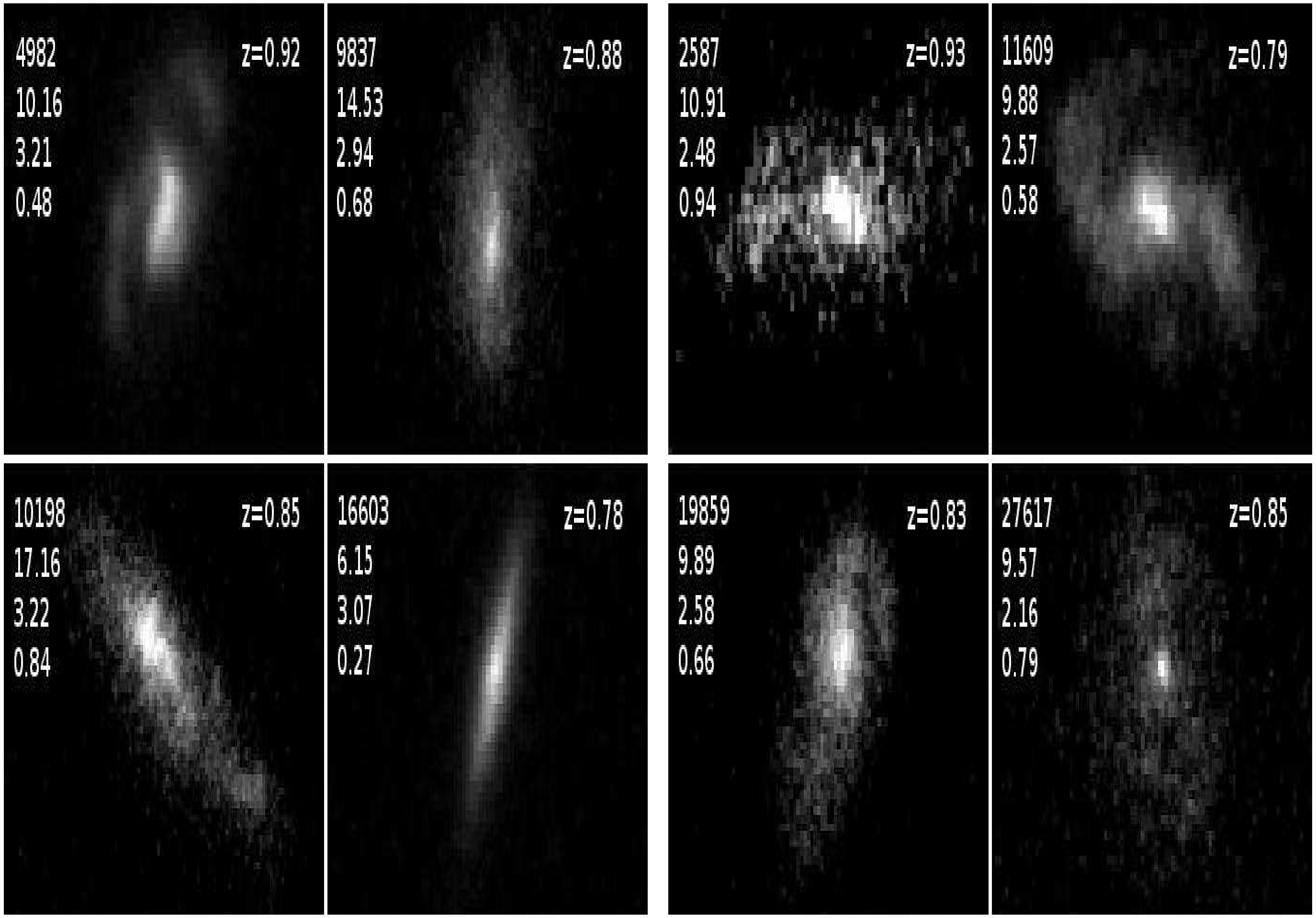
Galaxies from HST CDFS & NASA Sloan Atlas
(Giavalisco et al. (2004), Blanton et al. (2005))



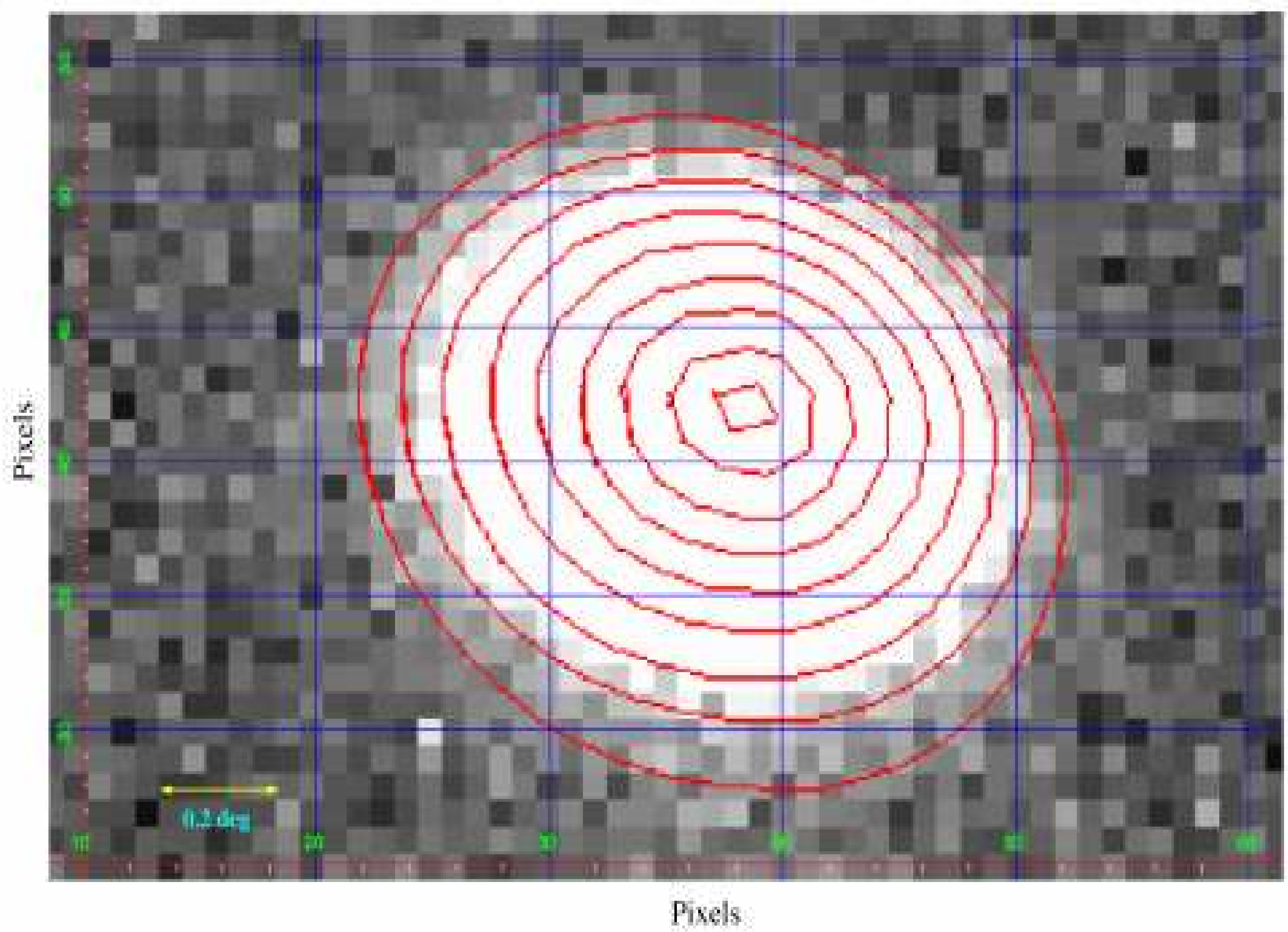
SDSS $0.02 < z < 0.05$ images,
discs with varied bulge types



HST $0.4 < z < 0.77$ images,
discs with varied bulge types



HST $0.77 < z < 1.0$ images,
discs with varied bulge types



"Ellipse" (Jedrzejewski (1987)) provides radial profiles of intensity, ellipticity and position-angle.

- **De Vaucouleurs function**

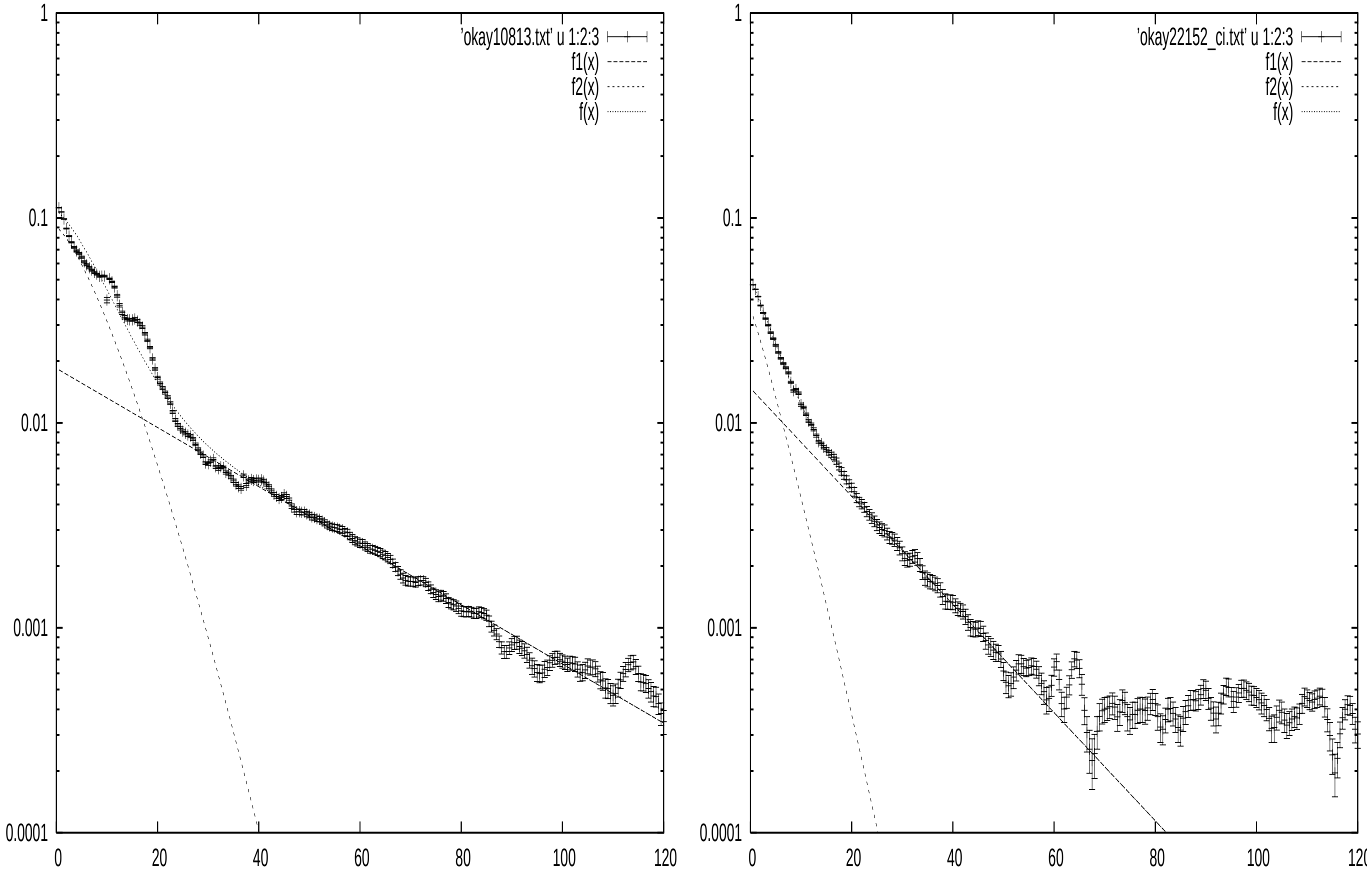
$$I(r) = I_e \, \mathrm{exp} \left(-7.669 \left(\left(\frac{r}{r_e} \right)^{1/4} - 1 \right) \right)$$

- **Sersic function**

$$I(r) = I_e \, \mathrm{exp} \left(-k \left(\left(\frac{r}{r_e} \right)^{1/n} - 1 \right) \right)$$

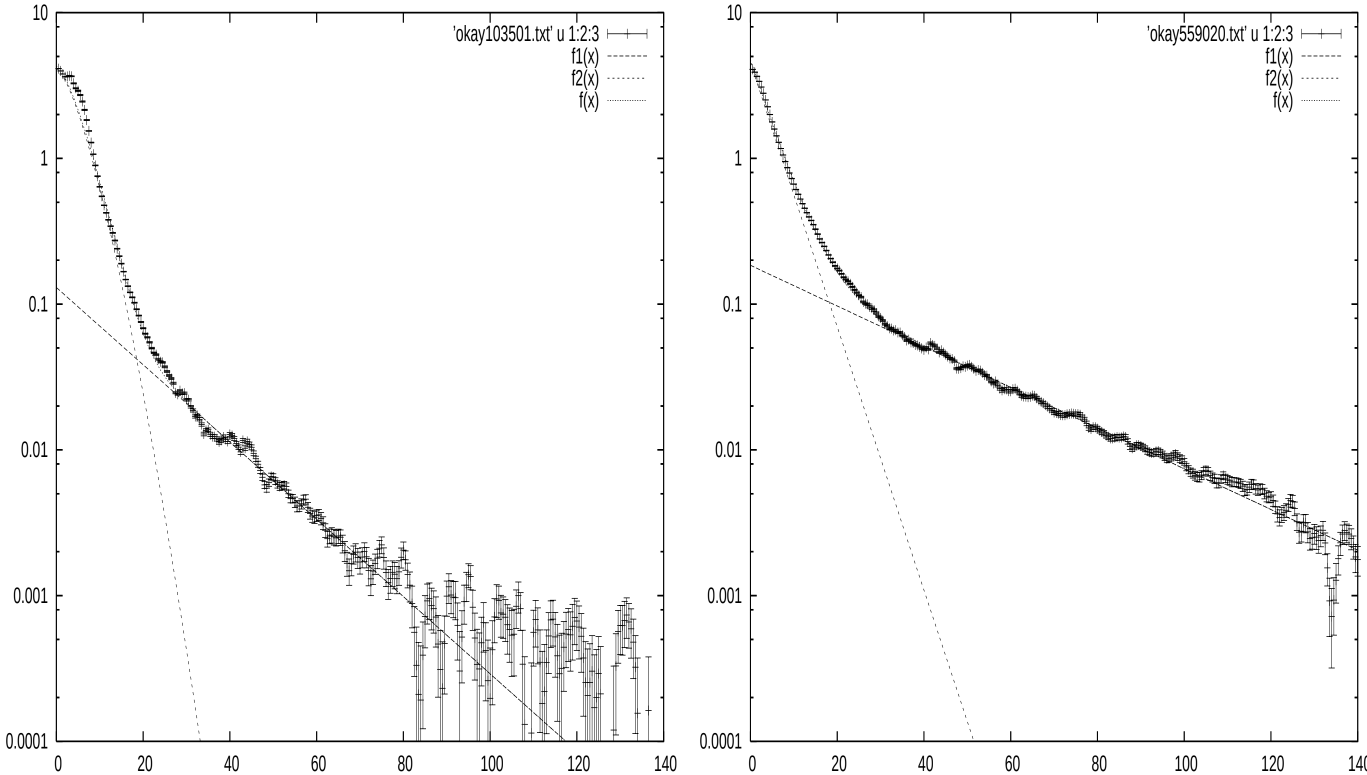
- **Exponential disc function**

$$I(r) = I_o \, \mathrm{exp} \left(\frac{r}{r_d} \right)$$



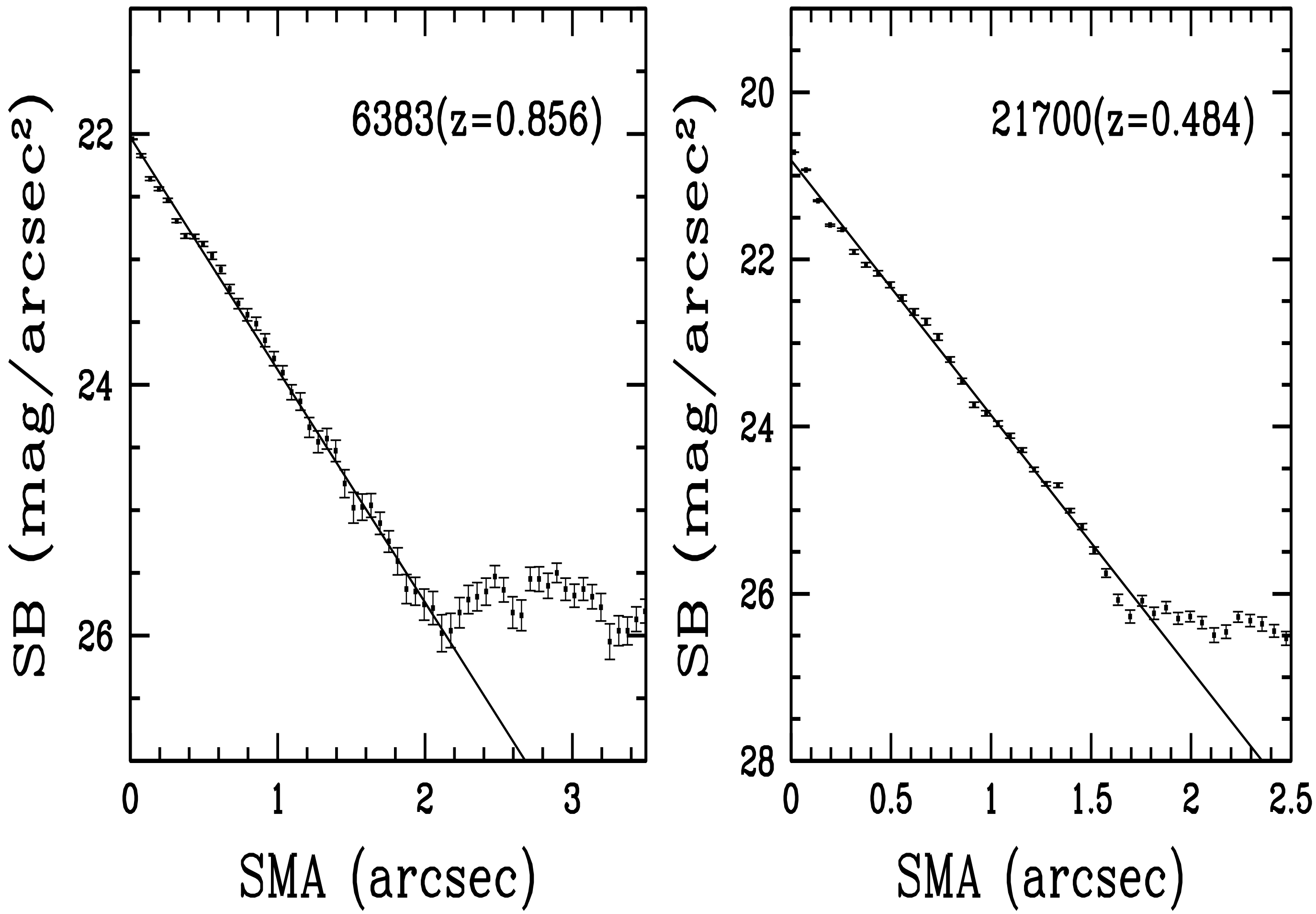
.

Fitting disc and bulge components.

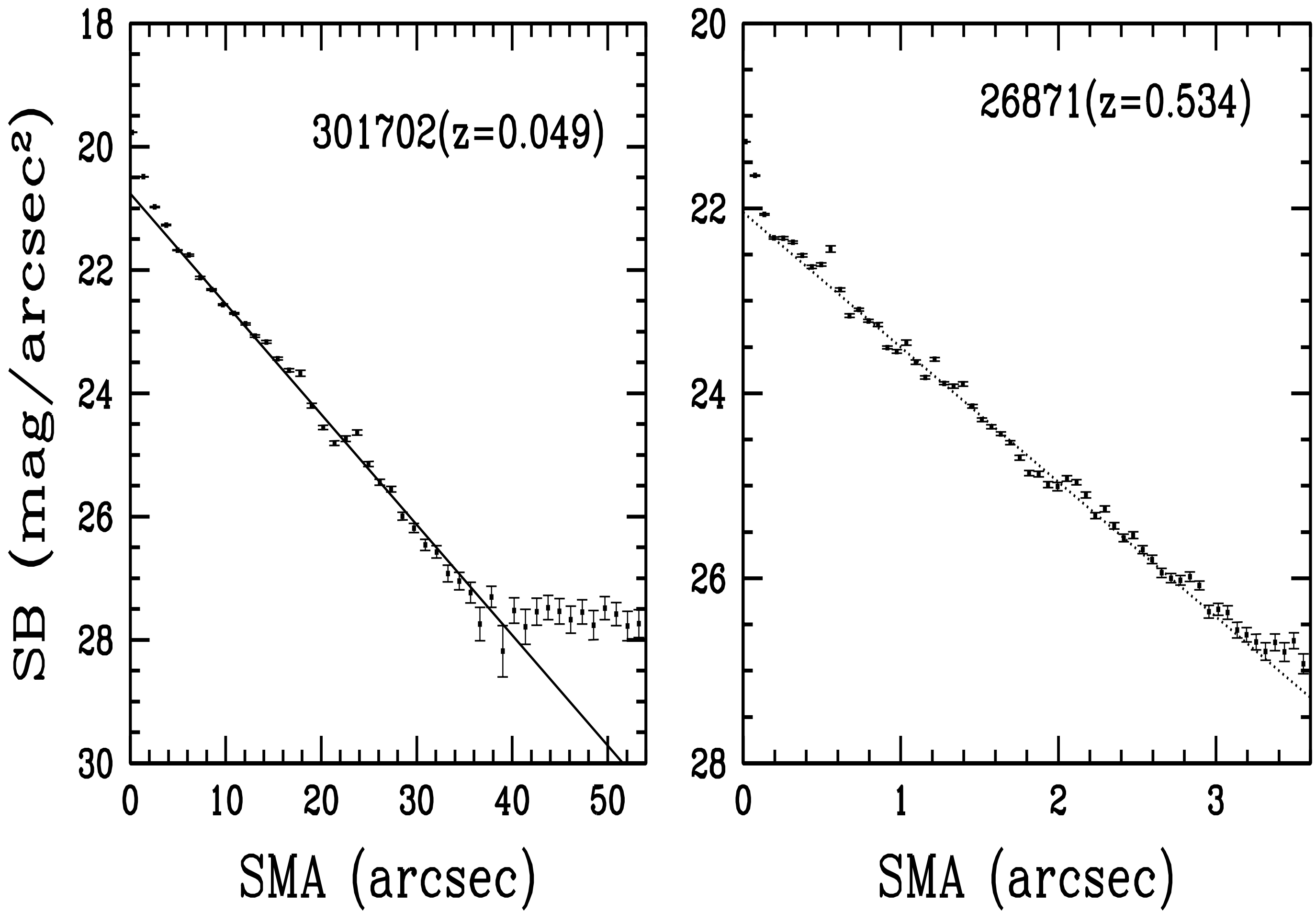


.

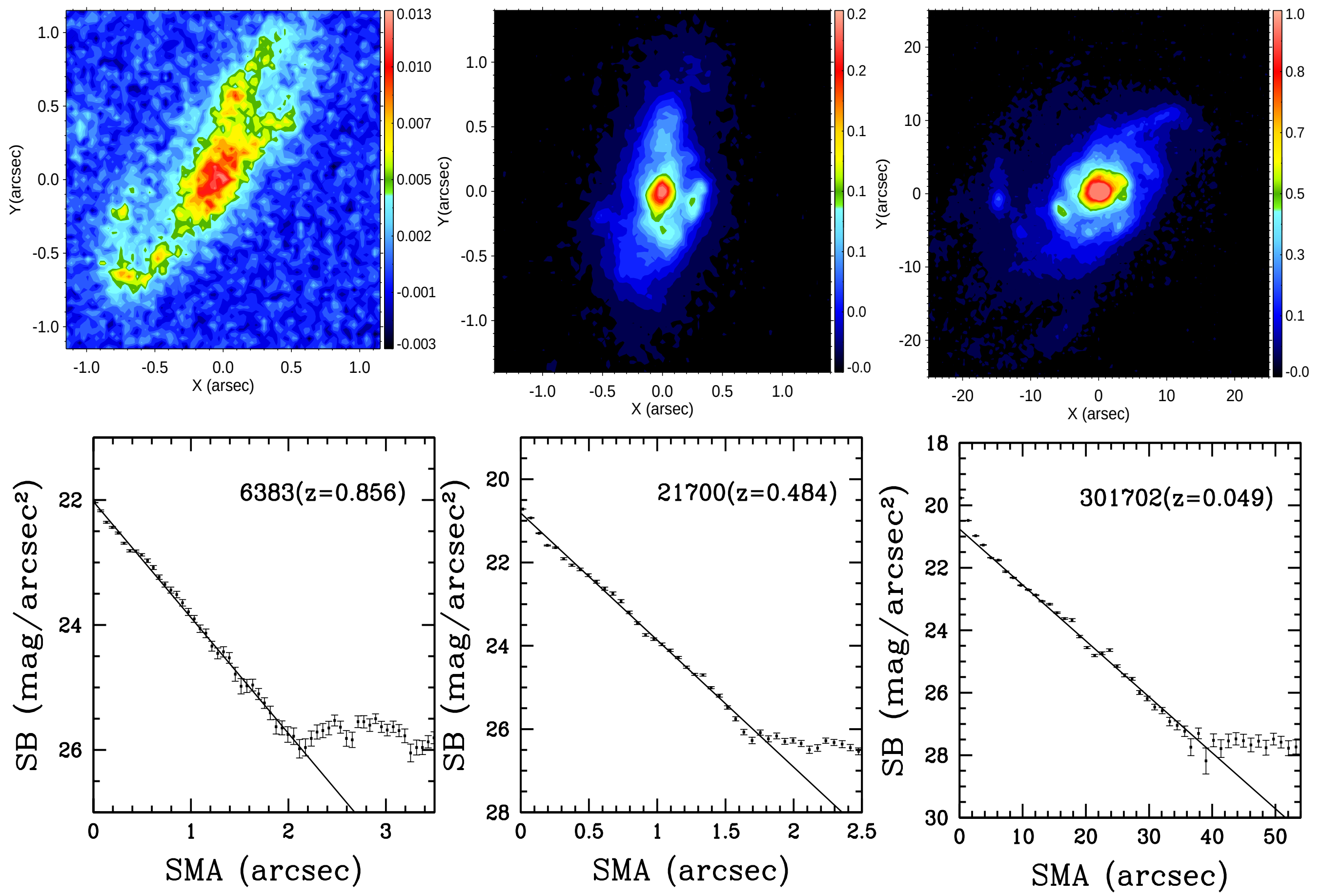
Fitting disc and bulge components.



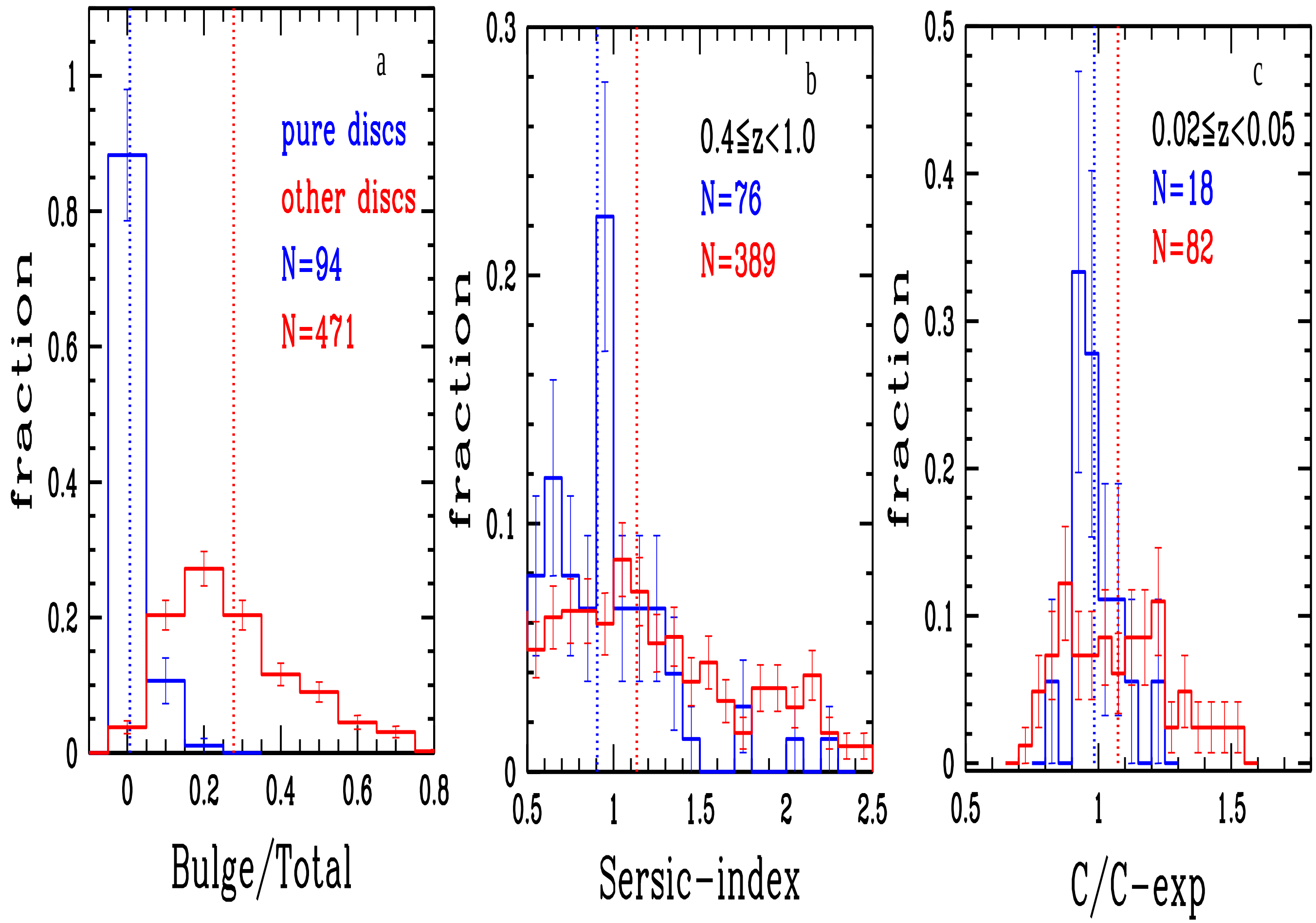
Discs with no bulge component!!



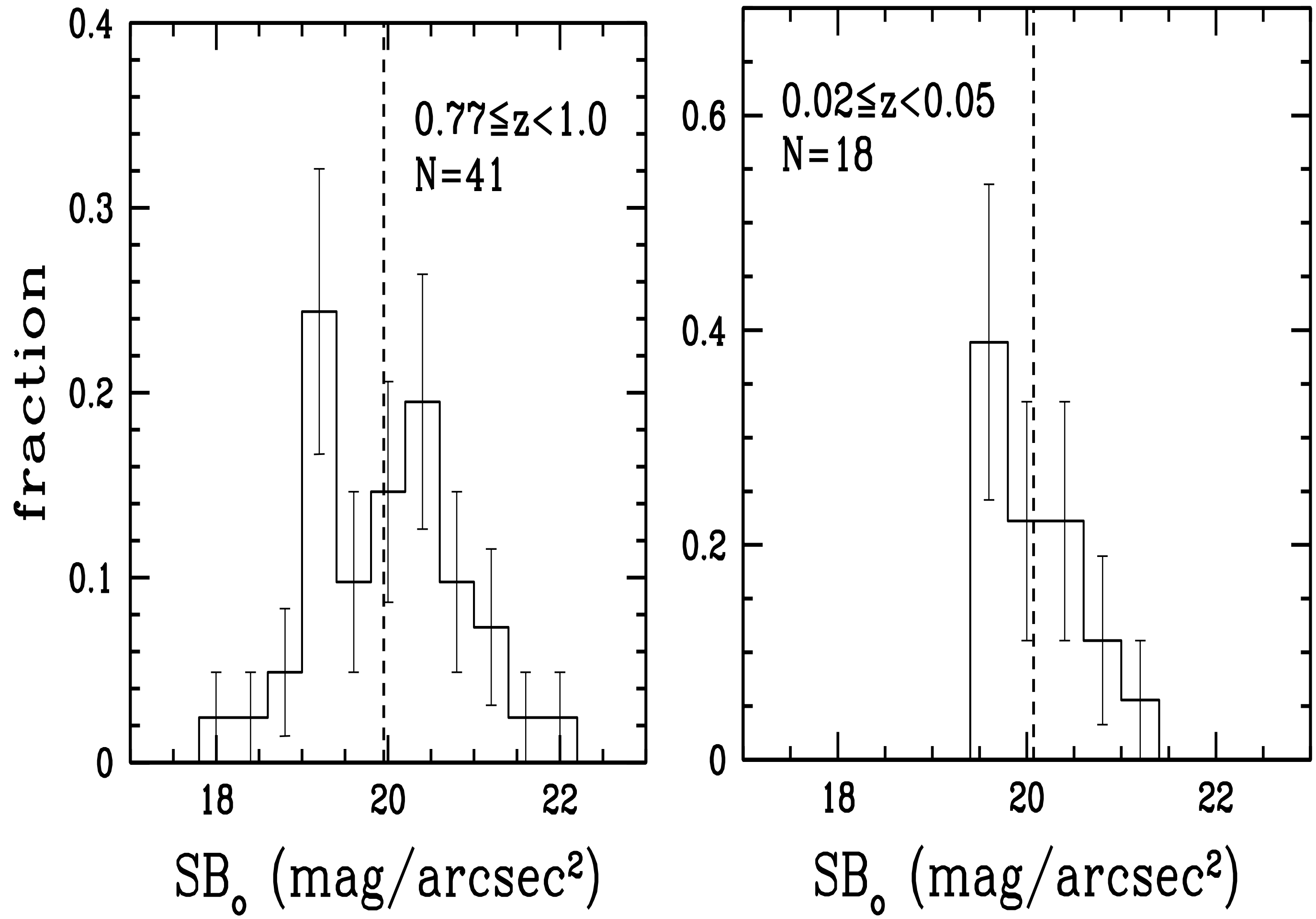
Discs with no bulge component!!



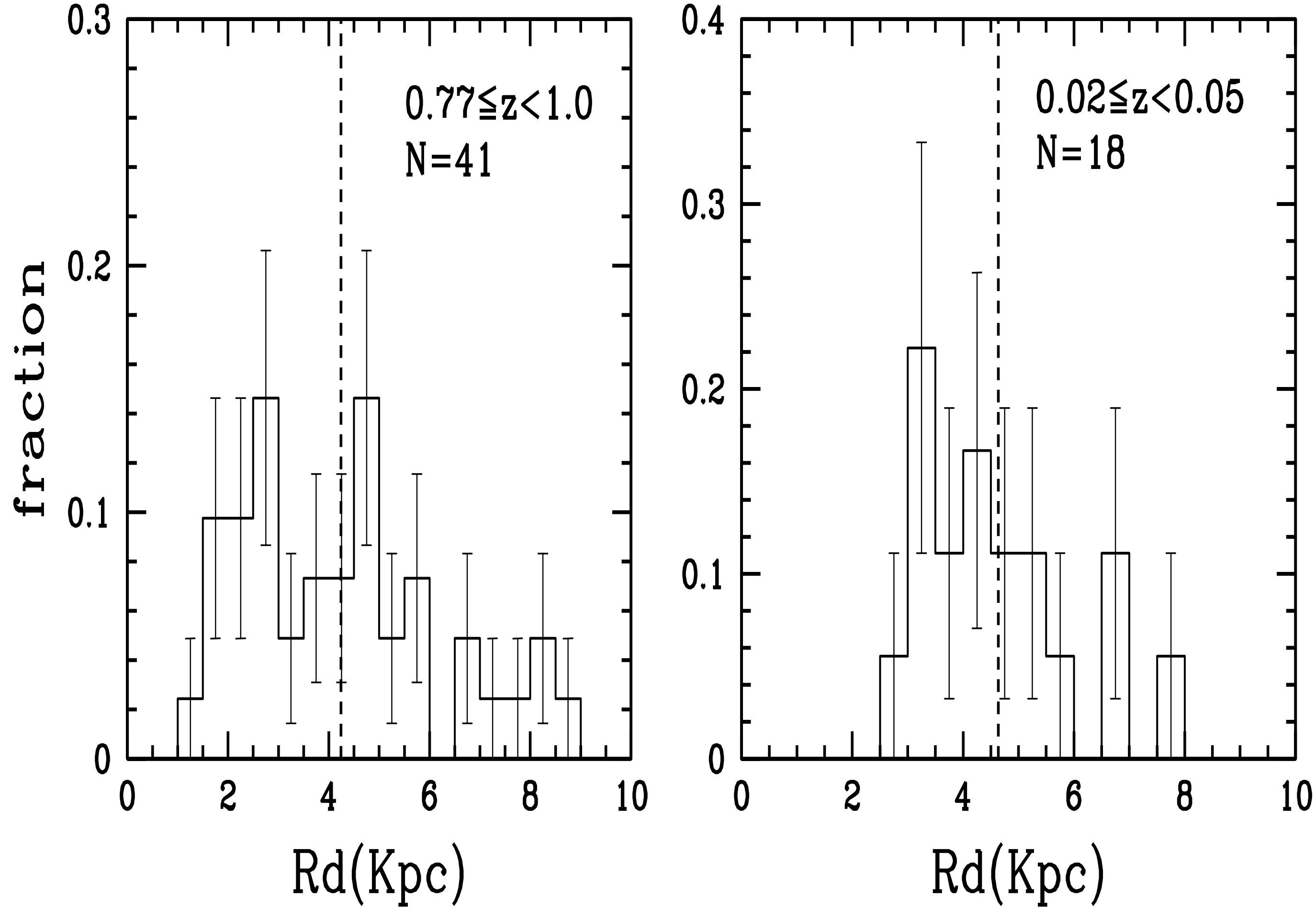
6383(z=0.856)
21700(z=0.484)
301702(z=0.049)
X (arsec)
Y(arcsec)
SB (mag/arcsec²)
SMA (arcsec)



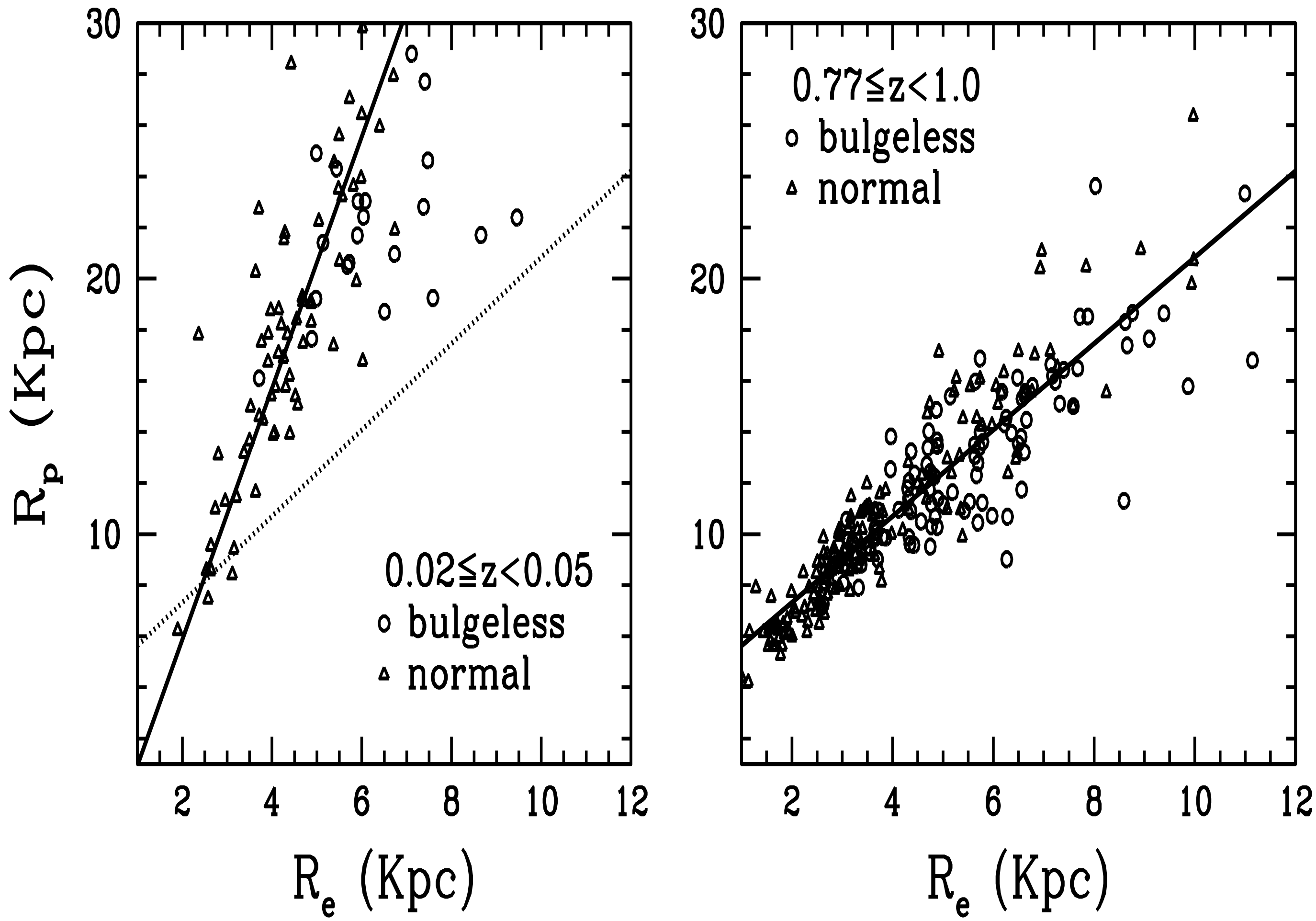
Confirming the selection of pure disc galaxies.



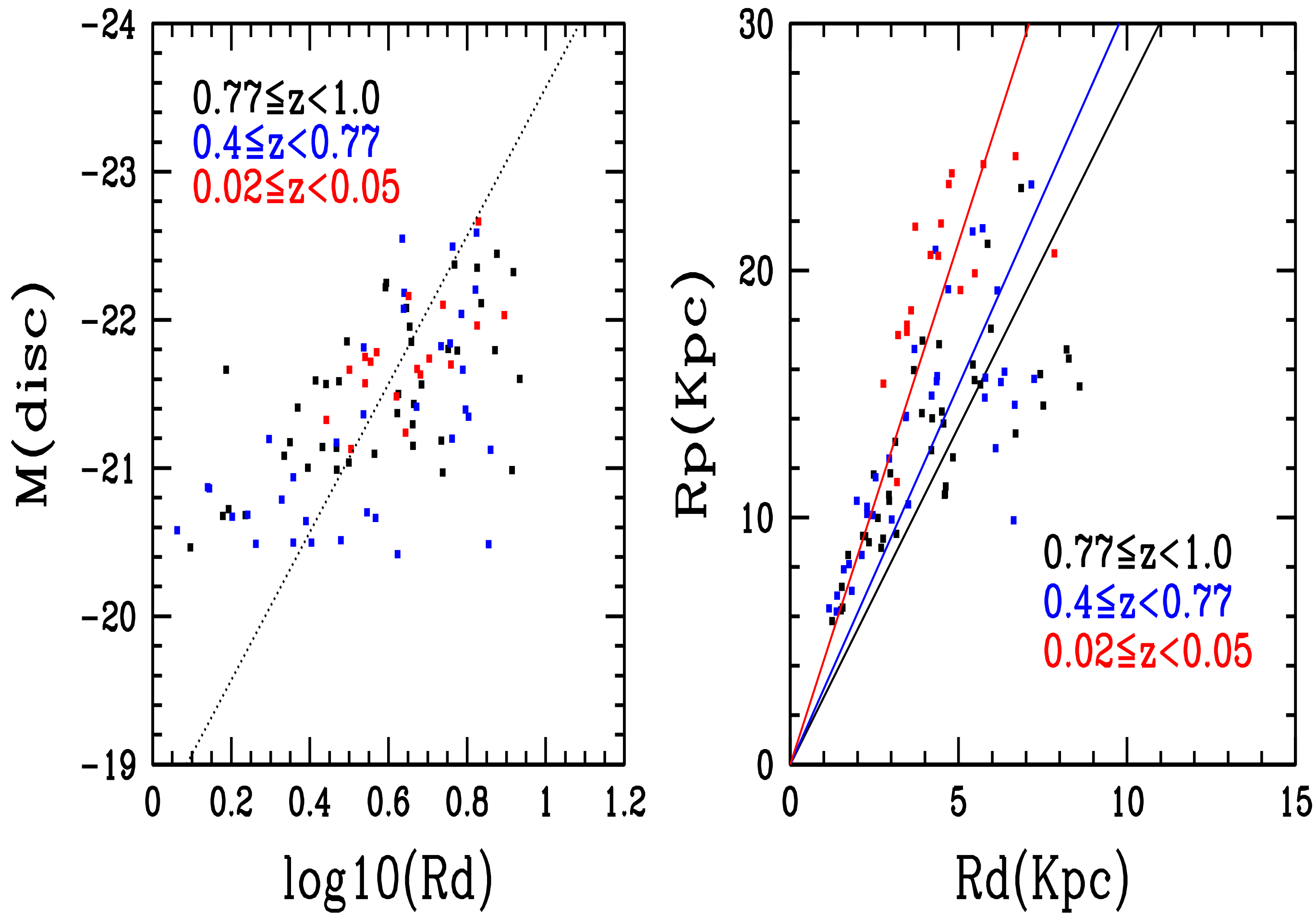
The SBo of pure discs does not evolve, remains in the range of 20.0($\pm$0.2) mag/arcsec^2, from z=1 to z=0.



The Rd of pure discs also does not evolve, remains in the range of 4.2($\pm$0.5) Kpc, from z= 1 to z=0.



The average optical size increases by ∼80% for discs with bulge and ∼60% for pure discs.



The exponential profile parameters do not evolve.

- **Inferences** Results support recent findings that for dynamically undisturbed systems, gas accretion to the outskirts is the only mode of stellar mass growth. Also, the accreted matter appears to be settling on the outskirts in such a manner that the inherent single exponential profile is not only preserved, it is enhanced to larger distances.

- **Present work** To study the formation and growth of different bulge types for the full disc sample.